



# Identifying social learning between Roman amphorae workshops through morphometric similarity



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## ABSTRACT

The aim of this study is to identify dynamics of social learning between amphorae workshops during the Roman Empire. The Baetica province developed a massive infrastructure of olive oil production that supplied the Western provinces of Rome for almost 300 years. The olive oil produced in this area was shipped through maritime and riverine transport networks in a standardized amphoric shape made in several workshops spread around the region. These workshops have generated a large amount of evidence but it is still difficult to understand through archaeological proxies how the production of amphorae was organized.

We apply here an evolutionary framework to find links between workshops through the morphometric similarities of the amphorae they produced. The suggested approach identifies how individual potters acquired and transmitted technical skills by exploring small yet statistically significant differences in the amphorae made in 5 different workshops. Multivariate methods are used to cluster a variety of amphorae based on morphometric measurements and the outcome shows that the analysis is useful even when a high degree of standardization exists, such as was the case for Roman amphorae (i.e. Dressel 20).

Results suggest that morphometric similarity is inversely correlated with spatial distance between workshops. This pattern suggests that pottery-making techniques were transmitted through oblique transmission with little or no movement of potters between distant workshops. The conclusion is that morphometric similarity may be an effective proxy to identify social learning dynamics even amongst workshops producing exactly the same amphoric type.

## 1. Introduction

The archaeological record is useful to identify the mechanisms by which humans learn from each other (Richerson and Boyd, 2005; Eerkens and Lipo, 2007). The analysis of archaeological proxies able to capture variability can help us find traces of the social learning dynamics of the techniques used to make them (Shennan and Wilkinson, 2001; Eerkens and Lipo, 2005; Gandon et al., 2014). This approach has been successfully applied to the material culture generated by small-scale societies, but it has seldom been applied to large-scale standardized productions (Shennan et al., 2015).

This paper explores the social dynamics of specialized production in the Roman Empire. We focus here on analysing large-scale production of a single amphoric type (Dressel 20) in a specific area. An evolutionary framework is used to identify social learning dynamics between pottery-makers (Shennan, 2008a; Mesoudi, 2015).

Specifically, pottery making is learned through a variety of cultural

transmission mechanisms depending on the organization of the community that made them (Neff, 1992; Shennan, 2002; Bowser and Patton, 2008; Hosfield, 2009). For example, vertical transmission is a mode of transmission where learning is transmitted from parents to offspring (similar to biological transmission); oblique transmission sees a master teaching a younger generation of disciples, whereas in horizontal transmission individuals of the same generation transmit their knowledge to other individuals of the same generation (i.e. workers from different workshops) (Cavalli-Sforza and Feldman, 1981; Acerbi and Parisi, 2006).

All these methods require communication and for this reason the techniques to make artefacts such as pots and amphorae should vary across geographical distance (Björklund et al., 2010; Shennan et al., 2015; Van Strien et al., 2015). If vertical or oblique transmission are predominant then material culture should be similar in nearby groups with high intensities of interaction (Hart, 2012). The underlying consequence is that it should be possible to identify the degree of

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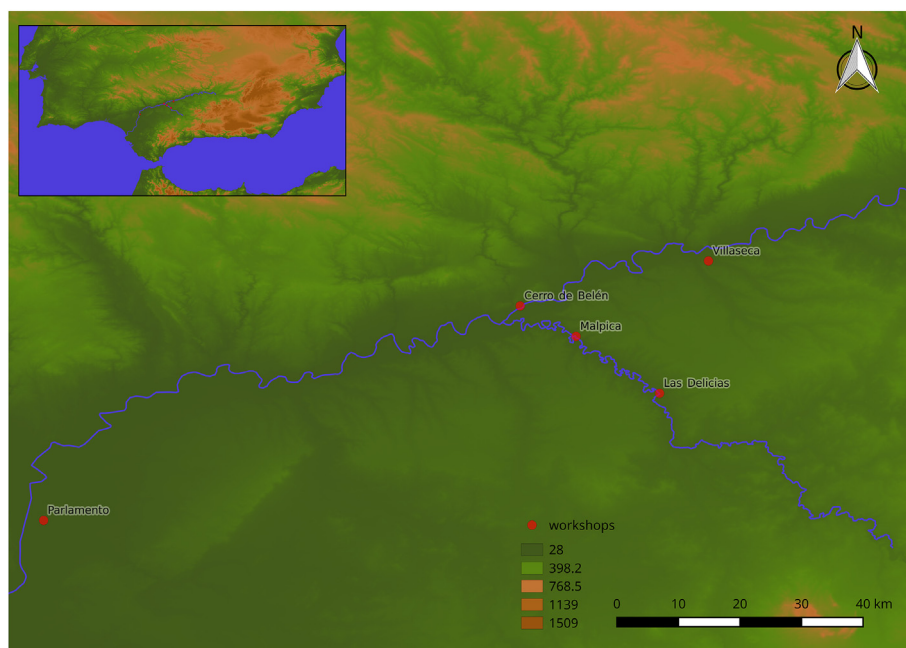


Fig. 1. The Baetica province during the Roman Empire. The location of the analysed workshops shows how Dressel 20 workshops were mostly distributed along the rivers Guadalquivir and Genil

interaction between workshops by quantifying similarity amongst the amphorae they produced; if apprentices moved between distant workshops then no differences would be found on this proxy while oblique transmission would be revealed by distant workshops exhibiting less similarity.

These hypotheses on archaeological proxies of social learning have been tested elsewhere (Roux, 2015) and it has been shown that hand-made pottery can be a good indicator of the different social learning mechanisms involved on the process (Neiman, 1995; Shennan and Wilkinson, 2001; Steele et al., 2010). However, cultural transmission on standardized productions such as the ones found during the Roman Empire has not been explored at the same level (Bevan, 2014).

The work we present here identifies learning processes of amphorae making in the case of the massive olive oil production organised during the Roman Empire. Olive oil was one of the most important products of the Classical Mediterranean world as it was used in almost all aspects of daily life including cooking, lighting and hygiene (Mattingly, 1988). The Baetica province (currently Andalusia, southern Spain) developed a massive infrastructure of olive oil production to face the demands of the Roman Empire. The product was shipped in large amounts of amphorae to distant provinces all along the Western provinces and specially to the city of Rome and the thousands of military garrisons deployed along the provinces in the border such as Britannia (Carreras Monfort, 1998; Funari, 2005) and Germania (Remesal, 1986).

Baetica was an important olive oil production and distribution centre for almost three centuries (Remesal, 1977; Berni, 1998; Remesal, 1998; Chic, 2005). The province had a strong connectivity through riverine transport that allowed inland producers to ship their products towards the trade networks through the Mediterranean and the Atlantic (García Vargas, 2010). The production of amphora shipping Baetican olive oil exhibits a sudden exponential increase as over a hundred of workshops were created to meet the volume of olive oil being produced. These workshops were located along the Guadalquivir river and its tributaries. The majority of amphorae produced in this area are classified as Dressel 20 type divided into a variety of subclasses (Martin-Kilcher, 1987; Berni, 2008).

Despite the abundance of Dressel 20 across thousands of archaeological sites, we still do not know how its production was organized. This challenge is common for all large-scale productions during the

Roman Empire due to the lack of written records discussing the topic and the difficulties of identifying adequate archaeological proxies that give clues on the process. Several studies have analysed amphorae using a diversity of approaches, from chemical analyses to large-scale distribution (Isaksen, 2006; Brughmans and Poblome, 2016; Rubio-Campillo et al., 2017). However, the structure of social learning that transmitted knowledge on how amphorae were made is still poorly understood. Were these workshops run by families or groups of owners without kinship? Did apprentices work in the same workshop where they were trained? Did potters work in more than one workshop? Were changes in production decided by workshops or by external actors? All these questions are linked to the social learning processes that took place in the workshops. Additionally, archaeological record shows that specialized production was highly organized and homogeneous both in terms of products and processes. As a consequence, amphorae made in different workshops do not exhibit a large degree of variations and they look identical: the same type of amphorae was produced over 300 years while similar stamps and information was recorded on them (Remesal, 2004).

We use here an evolutionary framework designed to improve our understanding of these large-scale production dynamics. If the system was mainly driven by oblique transmission mechanisms then no potters would be moving to distant workshops. As a consequence, amphorae produced in nearby workshops might share more similar traits than with the rest of the production. On the other hand, if horizontal dynamics were common then this correlation with spatial coordinates should not be present as workers would share their methods across the entire study area.

The paper can be summarized as follows. The next section introduces the dataset and the methods used to analyse it. Section three presents the results while the last part discusses the outcomes and highlights the main conclusions of the work.

## 2. Material and methods

### 2.1. Workshops

Our sample comprised 413 Dressel 20 amphorae collected from the five Dressel 20 workshops most intensively excavated during recent

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